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AN
ESSAY
ON THE
METHODS OF SUPPRESSING
HÆMORRHAGES
FROM
DIVIDED ARTERIES.

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ADVERTISEMENT.

*N*otwithstanding much has been lately wrote upon this subject, yet no one seems to have considered it thoroughly. The author therefore begs leave to offer the result of his enquiries concerning this matter, imagining, if he has gone farther than other writers, that he is doing some service to the Art of Surgery, though this Essay should (as it probably will) fall short of perfection.



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INTRODUCTION.

WHOEVER takes a view of the late well-intended attempts to recommend a less painful method of suppressing the hæmorrhage from divided arteries, than is generally practised, will find that these writers have omitted to ascertain by proper experiments the principles on which the suppression depends ; and upon enquiry the different theories which have been invented by other writers will appear to be greatly deficient, and destitute of any fact or experiment sufficient to evince their truth.

Indeed

Indeed Mr. Gooch * has considered this affair nearly in its true light; but as what he says is only conjectural, it seems not to have gained preference to the other hypotheses which have been advanced; a very ingenious surgeon at this time adopting the opinion of Pouteau †.

In fact, this part of practice has always been defective, by not learning from nature the true intentions to be answered. Hence, from not acting upon right principles, remedies have been applied at random; and nature has often effected a cure, in opposition to the most barbarous and im-

* Cafes, p. 140. London 1758.

† Mr. White on Spunge.

proper

proper applications. The different specifics which have been cried up and in vogue, and the multiplicity of remedies, sufficiently point out the uncertainty with which this subject has been treated; for had the principles on which we were to proceed been ascertained, the most effectual applications would easily have been discovered, and the rest discarded as useless. And though since the needle and ligature were introduced, we have been more steady in our practice, yet I apprehend we have, even in this particular, been not quite free from imperfection.—And were we not so unsettled, as to be near giving it up for remedies recommended with only supposed advantages?

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x *INTRODUCTION.*

The following essay is therefore intended to supply these defects; and I hope, by proper experiments, and giving a new light to several facts, I have both ascertained the principles on which a suppression of the flux from divided arteries depends, and what method most safely and effectually, under different circumstances, answers this purpose.

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D I V I D E D A R T E R I E S.

C H A P. I.

*Of the natural or spontaneous suppression of
Hæmorrhages from divided arteries.*

WHEN agaric of the oak was first introduced in England, for suppressing the hæmorrhage from divided arteries, I made several experiments to try in what manner it produced its effects; and I was soon convinced, that it had no other property than that of adhering

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hering

hering close to the mouth of the vessel: this circumstance, together with considering how often the smaller arteries close themselves by their own natural contraction, and that it was common for very considerable arteries to be closed in the same manner, when the impulse of the blood was abated by the swooning of the patient *, led me to imagine that the same thing must of course happen in the large arteries, provided the passage of the blood through them be first intercepted for a time, and that the close contraction which was observed in those arteries † to which the agaric had been applied, was intirely owing to the course of the blood being impeded by blocking up the end of the vessel.

Every day's experience confirmed me in this opinion; for I found that the flux from very considerable arteries was easily and effectually suppressed by only making a perpendicular pressure a few minutes upon the end of the vessel.—But, in order to be more

* See Baron Van Swieten's Comm. vol. ii. p. 34. and Phil. Trans. N° 449. p. 313.

† Warner's Cases, p. 136.

certain

certain about this matter, in the latter end of the year 1755 I made the following experiment.

After tying a large horse down, Mr. Peale of Maidstone, then with me, took off one of his hind legs about the middle of the thigh: immediately upon the bone being divided, the horse drew the stump towards his body, at which time the tourniquet slipped off, and five arteries, the least of them about the size of a wheat-straw, some near as large as a goose-quill, and one much larger, poured out with great vehemence; but an immediate stop was put to the flux by a person pressing with both hands upon the wound; and by continuing this pressure fifteen minutes, the vessels became so firmly closed as not to discharge the least drop of blood. However I passed a needle and thread round one of the largest, intending to make an experiment with the ligature.

The pulsation at first was very plainly seen at their extremities; but after some time it became less perceptible, and the wound was

4 *On the Methods of suppressing*

covered with tow, which was kept on with very slight bandage.

The horse was kept alive forty-eight hours after the operation ; and though he tumbled about and struggled much in attempting to raise himself up, yet there was not any return of the hæmorrhage, nor did there appear the least pulsation.

After he was killed we dissected the thigh, and found that the bleeding was not suppressed by congealed blood, but by all the vessels being quite close contracted for near an inch or more from their extremity.

After this I made more experiments of the same kind upon brutes with the same success, and always found, upon dissection, the ends of the vessels close contracted for a considerable way : by removing my fingers from time to time, while I pressed upon the vessel, it was easy to discover this contraction taking place by a gradual decrease of the stream of blood ; but in August 1757 the following case gave a further light to this matter.

Jos.

Jos. Ayre of Caudwell, about twenty years of age, in being bled had the misfortune to have the humeral artery opened along with the basilic vein, and the operator with much difficulty suppressed the hæmorrhage by bandage: however a tumor with great pulsation soon began to arise in the part wounded, which in six or seven weeks increased to the size of a pullet's egg.

The nature of the tumor was at once evident, and an eschar on the upper part of it being upon the point of separation, determined me to perform the operation for the aneurism.

The impulse of the blood against the ligature at the time of the operation was very great; and as part of the artery (whose diameter was considerably enlarged) was exposed, its pulsation was remarkably visible: but upon removing the dressings the third day afterwards, the pulsation could neither be seen nor felt nearer to the ligature than an inch and half; whence I was led to conclude, that the artery had collapsed and gradually closed itself
up

up to the nearest lateral branches, as the resistance towards the ligature abated from the blood passing through those vessels.—And it appeared to me self-evident that nature always took this step to suppress the hæmorrhage from divided arteries, when I reflected that the same circumstance constantly happens, when the umbilical vessels are divided at the birth of the foetus.

However, as I did not look for the lateral branches in the experiments mentioned, I cut off another horse's tail near his body, and suppressed the hæmorrhage by pressing a few minutes with my fingers; and by a careful dissection the next day after he was killed, I found that the conclusion I had drawn was (in this subject at least) perfectly right.

Is it not owing to this cause that an hæmorrhage does not follow those mortifications, where the greatest part of the limb is destroyed and separates? For if the great vessels were closed no farther than where the mortification ends, a flux of blood must of course ensue upon the coming away of the dead

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parts.

parts. Is not this evinced in a case lately published by Mr. Antrobus *? where, though the mortification stopped only two inches above the ankle, yet it is probable that the large arteries closed themselves as far at least as where the femoral artery divides below the knee; because neither pulsation nor hæmorrhage appeared when the leg was taken off.

It will not, I imagine, appear at all surprising, that the closing of the end of the vessel an inch only, or perhaps less, should be sufficient to resist the force of the circulation, when it is considered, that this impulse against the end of the artery immediately becomes less, and soon intirely ceases, from the blood upon meeting with resistance dilating and passing through the nearest lateral branches; as is fully evident from the gradual decrease, and at length the total disappearance, of pulsation.

* Med. Observ. & Inq. vol. ii. p. 152.

Nor is this contraction of the artery and the alteration in the course of the blood long in taking place, as appears from the experiments mentioned: and besides these, in many instances I have observed, that arteries as large as those we commonly meet with in cutting for the stone, or in taking off scirrhus breasts, &c. will for the most part, if they are wholly divided, be effectually closed by pressure in three or four minutes. And if in taking off a leg, we intercept the course of the blood longer than is usually done, most of the arteries will often be closed, if the patient is in a tolerable good habit, as I have learnt by tying the large vessels without loosening the tourniquet.

I took off a woman's leg near the middle of her thigh, and tied the large artery without loosening the tourniquet; upon setting it at liberty, we observed some blood draining down the muscles from one artery only, and though it had contracted itself so much as scarce to admit the passage of any blood, yet by the pulsation it appeared to be a very considerable

siderable vessel, and on this account the ligature was used.

Several more, which did not bleed, were discovered by a strong pulsation at their extremities; and therefore, instead of immediately dressing the patient, we waited ten or fifteen minutes, and gave her wine to raise her spirits, so that we might see whether they would bleed or not, and thereby prevent our being alarmed with a fresh hæmorrhage after she was put to bed: but during this time the pulsation gradually disappeared, and the bleeding was effectually stopped.

Indeed, since I have attended to this circumstance I have seen it so often happen, that I am well convinced in amputations larger vessels have been trusted with lint and flour than has generally been imagined; and that when a fresh hæmorrhage returns some hours after an operation, it is not from small arteries being dilated by an increased motion in the blood, as has generally been thought, but to the principal lateral branches which had closed themselves being again forced open.

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That the large arteries are also closed in a very little time, does not only appear from the experiment made upon the horse's leg, but likewise in several of those cases where the course of the blood was intercepted, either by the application of agaric or other fungous substances, especially a case related by Mr. Warner *, where, " in an hour after the operation, the mouths of the vessels were found " totally contracted, so as to resist the whole " force of the circulation ;" after which they probably, like the umbilical vessels, shrink into a perfect cord, and become impervious.— And does not nature seem to point out, that intercepting the passage of the blood for a while, is all that is required from art; as some animals by instinct, in separating their young from the placenta, lacerate the cord with their teeth, whence probably the ragged fibres stop up the end of the vessel by collapsing over each other?

Seeing then that nature suppresses the hæmorrhage from divided arteries by the natural

* Cases, p. 147, 148.

contraction of their circular fibres, when the impediment to this contraction is removed, by intercepting the impulse of the blood, let us fairly enquire what method best answers this purpose, beginning with the ligature, on account of its having been long in general use.

C H A P. II.

Of the Ligature.

THE success which has hitherto in general attended the ligature, is a full proof of its efficacy; and it is evident nothing can more powerfully intercept the course of the blood, provided it can be properly applied: and though it seems to have been a general opinion, that the vessel only unites in that part where the stricture is made, and preference has on that account been lately given to other remedies*; yet I imagine, from what has been said, it will readily be conceived that it is also in this case closed by its own natural contraction, and which will be found true, if the end of the artery can be discovered.

But this is often difficult, it being at first commonly covered with the swelled muscles,

* *Philos. Transf.* vol. xlvii. art. 94.

and after some time sends out (like all other parts) new flesh, and cannot be distinguished: therefore as a proof, I shall observe that the artery which was tied in the horse's leg, was not only closed below, but also at least half an inch above the ligature; so that every advantage possible, in regard to stopping the blood, is obtained, provided the end of the vessel does not separate and come away with the ligature; for though no inconvenience will follow, if the stricture is made some distance from the lateral branches; yet, if it happens to be very near, a fresh flux of blood must ensue, which is probably one reason why there are some few instances to be met with of the arteries bleeding again some time after they have been tied.

But, from attending several years to this particular, I find that the end of the vessel does not so often come away as is imagined, and that a separation may be generally avoided, as it only happens when the ligature is thin, and very little substance is comprised along with the vessel in the noose; whereas when we take in a proper quantity of the circum-
jacent

jacent parts to defend it, and the ligature is of a proper size, upon digestion coming on it becomes loose and slips off, leaving the vessel firmly closed and intire.

However, that we may avoid with as much certainty as possible the separation of the end of the vessel, I would advise that the ligature should be made of long twelve-penny flax, without either being the least twisted or waxed further than just the end, to make it pass thro' the eye of the needle; and if it is rubbed over with some soft digestive, it will slip easily through the flesh.

This will be found sufficiently strong for the purpose for which it is wanted, without the least danger of its injuring the vessel; nor need the compressure be greater than is just necessary to intercept the passage of the blood, which will still add to the security in this respect, and at the same time produce other advantages, as will be observed in their proper place.

And

And further, if the ligature can be properly applied, it is equally effectual, whether the artery be only in part or intirely divided; whether it is at liberty to retract itself, or adheres to an undivided muscle or the bone. And if the needle can be passed a proper depth into the adjacent parts, no accident can remove it, if they are sound, till the state of contraction and inflammation is over; when, in general, all will have been done that is necessary, the pressure of the swelled muscles most effectually assisting the closing of the vessels.

Nevertheless, along with these advantages it must be confessed, that great pain often accompanies the use of the ligature; which, where it cannot be avoided, would make us prefer any other remedy that is equally safe and unattended with this inconvenience. But it very fortunately happens, that where the ligature is most wanted, it may be applied with very little or no pain, if properly managed; for the large arteries are commonly furrounded with a considerable quantity of cellular membrane;

brane; and if we only take in with the vessel this nearly insensible substance, the patient seems undisturbed during the operation *: and upon enquiring of several at the time of tying the vessel, whether they felt much pain, I have always been answered in the negative; and though the nerve which accompanies the artery is inclosed in the noose, it makes no difference in regard to this circumstance.

Perhaps it may seem strange to those who have not considered this matter, that great pain should not arise upon a nerve, which is an organ of sensation, being compressed; but there are several instances in the practice of surgery, besides this, which lead us to imagine that the nerves are incapable of being irritated, till they are divested of their coverings, unless you penetrate through their coats down to the medullary substance †; consequently,

* See *Monro, Ed. Med. Ess.* vol. iv. p. 264.

† In performing the operation upon an aneurism some time since, I accidentally had an opportunity of observing the difference betwixt pricking and tying a nerve.

In passing the needle under the artery it penetrated the nerve, upon which the patient instantly cried out of great pain

quently, when they are also defended by the artery, fat, and cellular membrane, they will still be less liable to be affected.

This may be illustrated by reflecting on the situation of the nerves in the bones, tendons, membranes, and the like; where they seem to be rendered insensible and incapable of being irritated by the compactness of the parts which invest them *, as appears from the

pain all down his arm, which ceased when the needle was withdrawn. But though the same nerve was afterwards inclosed in the ligature along with the artery, the patient told me he only felt a prickling and numbness, which soon went off.

* It does not hence follow, that “wounds of the tendons are the most easily cured of all others only by the help of nature, without any trouble or bad symptom,” as an author of eminence has asserted: and as it will explain part of what is hereafter said about convulsions, we shall just observe, that though the tendons in their natural state are void of sensibility, yet, when they become swelled and tense, more painful and troublesome symptoms generally arise in these than in other wounds; probably from the particular structure of the part, by which the obstruction rises higher and is long in terminating, and the nerves during this state are put more upon the stretch than in any other part of the body.

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the new flesh which follows their being wounded, being sensible, and again losing its sensibility, as the part acquires its natural texture.

With this we may observe that numbness, the usual consequence of compressing a nerve, cannot here give any uneasiness, because the parts to which the nerves were distributed are removed.

However, when the vessels are so situated that muscular fibres must of course be inclosed, the ligature will unavoidably be attended with considerable pain; owing probably to the nerves being divested of their coverings, and their medullary substance alone expanded over every fibre of a muscle; not, I imagine, in the form of papillæ, but in the

But this does not hold good when a tendon is much lacerated, or a large wound is made in any other tendinous part; for then they remain insensible, and give no other disturbance than from the length of time they take to separate; very likely from the obstructed fluids being freely discharged, and the nerves being in a state of relaxation.

same

same manner, though much thinner, as the retina in the bottom of the eye *.

But this pain is only momentary, because whatever is inclosed becomes nearly insensible upon the stricture being made. If the ligature recommended is used, the parts will be

* If I am not much mistaken, in tracing the nerves through the muscles I have seen them become a perfect mucus in this manner; and whoever will compare, by the help of a proper glass, the medullary part of the brain or a nerve cut open, with muscular fibres, which are not dried by being exposed to the air, will find that they are covered with a kind of pulp that has exactly the same appearance. And does not an observation of Haller's (*Sensib. & Irritab.* p. 59.) seem to confirm this opinion; for in attempting to prove that irritability resides in the glutinous mucus, he says, "the most irritable parts are deprived of that quality only by robbing them of this mucus by drying;" which is easily explained, if instead of mere gluten, this proves to be the medullary part of the nerve.

Hence too we may easily see, how every part of the body (except those which are secured by a particular structure) is liable to be affected by the point of the finest needle. And how pain is carried by consent of parts all over the body, neither of which can be well accounted for, if the nerves are supposed to continue distinct cords to their extremities.

less irritated ; and whether the absolute security against a future hæmorrhage does not fully compensate for the uneasiness the patient feels on this account, may be gathered from what follows.

But it is thought, “ that the ligature, by
“ compressing the adjacent nerve, is some-
“ times productive of convulsions.” Now as no facts are brought to support this opinion, and as I have never yet seen any accident of this kind happen, though I have always, without regarding the nerve, freely used the needle and ligature ; nor, upon strict enquiry, found one instance of its happening amongst an extensive surgical acquaintance, I am induced to think with Mr. Sharp *, that the doctrine of convulsions being caused by the tying of a nerve is merely speculative, and seems, though the theory is changed, to have taken its rise from the arguments brought against Parey, when he first introduced the practice of tying the arteries, and since to have been copied from one to another by succeeding writers.

* Crit. Inq. p. 291.

But is it not probable that in this instance, as well as many others in surgery, by quite altering the meaning of the word NERVUS we have made those symptoms follow the tying of a nerve, which should have been considered only as the consequence of pricking a tendon? for long after Parey's time NERVUS was used to signify TENDON, and by "nervosam aliquam partem, vel nervum†," &c. there is great reason to think Parey's adversary meant a tendon or any tendinous part; especially as he supports his opinion by shewing, that for fear of the accidents described, Galen durst not stitch transverse wounds till he had first discovered the *aponeurosis of the muscles*,

However, we will consider this matter in the light it now stands; and for this purpose we may observe, that the ligature seems only

† Nam si acu nervosam aliquam partem, vel nervum ipsum pupugerit, dum ita novo & inusitato modo venam absurde conatur constringere, nova inflammatio necessario consequetur, à quo convulsio, & à convulsione cita mors. See Parey's Surgery, p. 1133.

capable

capable of irritating and of totally obstructing the nerves.

Now as the nerves upon the muscular fibres are very easily irritated, a theory plausible enough may be invented to shew, that in certain habits convulsions will come on upon their being tied; but then this would most probably happen at the very time they were irritated *: so far from this, no one that I know of has even pretended to say, that he has seen any patient fall into convulsions at the time the stricture was made. It is true there are instances where convulsions have instantly been brought on by irritation †; but they seem not to have any analogy with the case in hand: for the parts were diseased, and in all probability had a more acute feeling than ever happens to the nerves in their natural state, and consequently different effects would arise.—May not the pain in this case, as it is smart and of short duration only, somewhat in the manner of volatiles applied

* See Sharp's Crit. Inq. p. 292.

† See Van Swieten's Comm. vol. ii. p. 47.

to the nose, rather enliven the spirits than bring on convulsions?

On the other hand, if convulsions arose in consequence of the nerve being obstructed, instead of being a symptom that but very rarely happens, they would either in a greater or less degree appear almost every time a large one was tied; for if these are, as is generally believed, distinct cords from their origin, the obstruction and its effects would be always nearly the same. But so far from this, convulsions of any kind are not more frequent where the large nerves are inclosed in the ligature, than in slight injuries where it is not used.

Lately Le Dran * seems to have biased the minds of people † in favour of this doctrine; but unfortunately his practice immediately contradicts his theory: for speaking of those who, in performing the operation for the aneurism, inclose the adjacent flesh within

* Op. Surgery, p. 428.

† Mr. Warner's Cases, p. 146.

the ligature, he says ‡, “ though by this method they tie the nerve together with the artery, yet it is very seldom any ill consequences ensue from thence, as the quantity of flesh included by the ligature prevents the nerve from being much compressed.” And does not the same reasoning hold good, as is already shewn in amputations, where as great a quantity of the neighbouring parts is commonly inclosed? Besides, when he tells us, “ that tying the nerve along with the vessel, sometimes brings on convulsions some days after the ligature is made.” He also informs us, “ that there will not be any danger of this happening, if we apply a button of *vitriol* when the dressings are first removed;” which, he says, “ gradually forms an eschar that includes the ligature, and renders it useless.”

Now in a few days the ligature becomes loose spontaneously, and is no longer capable of doing injury. The parts being now inflamed and more sensible, *vitriol* will act with

‡ Loc. cit. p. 409.

great violence upon the nerves ; so that if no ill effects arose from this complicated treatment, much less could they arise from the ligature alone.

If the convulsions then were not the consequence of the dying state of the patient *, is it not probable they were owing to the nerves being irritated, either with acrid matter or some other cause ? for it is well known after the inflammation comes on the nerves become tense, and acquire a more acute feeling, and sometimes, where the fluids are very acrid, in few days are rendered so extremely sensible, as to bring on convulsions upon the slightest touch : and this seems to hold equally good in regard to the locked jaw, which within these few years has been said, “ sometimes
“ to come on in consequence of the stricture
“ made upon the arteries and their neighbouring parts by ligatures ;” for in all the cases of this kind which have come to my knowledge, it appears not to have happened till the injured part has been inflamed and painful. In wounds it has often come on,

* Sharp's Crit. Inq. p. 292.

when there has been the greatest reason to believe that the habit was become bad *, and the parts extremely sensible from a long continued flux of acrid matter falling upon them. But it seems most frequently to have occurred in wounds of the joints and other membranes †, where the nerves being put more upon the stretch are more liable to produce this terrible symptom, which seems only to differ from other convulsions in its degree of violence, and affects those, probably, where the whole nervous system is in a most extreme degree of irritability, as appears by the large and repeated doses of opium necessary to quiet the spasms.

From the whole then of what has been said, there is reason to acquit the ligature of

* Dr. Clephane says, “ In all the cases of the locked jaw I ever saw, the blood appeared of a loose texture, “ never fizy.” *Med. Ob. & Inq.* vol. i. p. 59.

† See Hippoc. de Morb. Popular. lib. v. p. 334. ver. 9. and p. 339. ver. 405 and 412. Cornarii Versione. Parey, lib. xii. p. 464. Baron Van Swieten’s Comm. Boerha. vol. iv. p. 182. Ranby on Gun-shot Wounds, p. 70 & seq. Warner’s Cases, case 13. Neal on Agaric, p. 32. *Med. Inq.* vol. i. case 1 and 7. and vol. 2. case 24.

being

being productive of those convulsions which sometimes have happened to attend a wound wherein it has been used.

Another kind of spasms, that are partial and attended with pain, are said constantly to attend the use of the needle and ligature; and it must be confessed, that while the needle is piercing a muscle a spasm is often produced: but it may with equal truth be observed, that it immediately ceases when the parts inclosed are numbed with the ligature. And it seems more likely that those spasms, which continue more or less for some time after the operation, arise from the nerves being irritated by the knife, by the air, and by the dressings; for whoever attends to this circumstance will find, that the spasms which follow, for instance, an amputation of the leg, immediately seize the muscles upon their being divided before any needle can be used. And we know by experience they will continue some time after the irritating cause is removed, in proportion as the nerves were more or less affected *. That a similar effect

* See Whytt on vital and invol. Mot. p. 20 and 242.

will be produced by the other causes assigned, there is reason to conclude from observing, that even the muscles of animals, immediately after death, are thrown into spasms by being exposed to the cold air; and spasms are also often brought on by touching naked wounds with dry lint.

Besides, spasms follow those amputations just in the same manner, where the vessels are not tied *; nor can the absence of this symptom with justice be ascribed to the omission of the ligature in amputations of the breasts †, because in this case the muscles, which are the seat of spasms, are seldom touched with the needle; the cellular and adipose membrane only being taken in with the vessel, and which, from their small degree of sensibility, give but little uneasiness: and out of many instances I do not remember any patient attended with *troublesome* spasms after this operation, though the needle and ligature were always used.

* Phil. Trans. vol. xlviii. part 2. p. 591.

† Ibid. p. 596.

Another objection to the ligature is, “ that
“ it increases the symptomatic fever, because
“ its application gives violent pain:” but
though it often gives smart pain for an in-
stant, it does not follow that it aggravates the
symptomatic fever, for the pain is only mo-
mentary, and whatever is included in the li-
gature immediately becomes so insensible, as
to give no future disturbance. It is true, an
inflammation will take place above the stric-
ture ; but as an inflammation of equal degree
would probably have occurred, though the
ligature was not used, very little difference of
pain can arise from this cause, as is evinced
by the symptoms following an operation be-
ing much the same, whether we use many
ligatures or few.

But the symptomatic fever seems not to
arise from the pain which accompanies or im-
mediately follows any part of the operation,
but to the distension which is caused by the
obstruction and inflammation that comes on
some time after in consequence of the division
of the parts ; for that pain which arises from
the nerves being irritated and disordered in
the

the operation, presently goes off, the irritating cause being instantly removed. And does not the symptomatic fever gradually come on, a few hours after the operation, as the parts about the wound begin to swell, and again decline as the distension abates, from the lymphatic vessels freely transmitting their contents?

Besides, from the account given us of the symptomatic fever following an amputation of the leg, where the ligature was omitted, we see * it came on about the usual time, and seems to have been nearly the same as when it is used. And though the symptomatic fever has been slight in amputations of the breasts †, where the vessels were not tied, yet it does not appear to be a proof that it is increased by the use of the ligature, because in this operation the symptomatic fever is for the most part, if not always, slight; for the fat in the cellular membrane easily melts down, and the reticular or membranous part

* Phil. Transf. vol. xlviii. part 2. p. 591. or Mr. Warner's Cases, case 29.

† Ibid.

sends out new flesh without giving much disturbance, and in this case these, with the skin, are the only parts wounded; for even when a schirrus adheres, it is separated from the pectoral muscle without doing much injury, as this operation, I imagine, is never practised when the adhesion is otherwise than slight.

With this we should remember, that the symptomatic fever, is always slight where the solids are relaxed and weak, in consequence of the small degree of force with which the blood is carried against the obstructed vessels. And is it not therefore more likely owing to this cause than to the omission of the ligature, that a slight fever only followed in those whose legs were amputated by Mr. Warner*, as all these patients were much reduced previous to the operation? And is not, in such habits, the symptomatic fever constantly slight, though the ligature is used.

It is also said that abscesses are the consequence of using the ligature, and that it some-

* Loc. cit.

times remains fixed to the last, so as to retard the healing of the wound; but these inconveniencies only happen when the needle is passed very deep, and may therefore be avoided by a contrary practice: nor is passing the needle deep at all necessary (if the parts are sound) as a small quantity of flesh or cellular membrane below the stricture will sufficiently prevent the ligature being pushed off by the impulse of the blood. However I would caution against extremes; for with passing the needle but a very little way the vessel sometimes may not be tied, and cause unnecessary trouble; if we therefore pass the needle only a moderate depth, the ligature will always come away in due time without inconvenience, or at least it may be taken away long before the wound is healed, without any danger of bringing on a fresh hæmorrhage: for as soon as digestion is complete, and the new flesh begins to rise, the ligature makes not any pressure upon the vessel; and though new flesh may have covered the noose, yet if we take the advice long since given by Monro *,

* Ed. Med. Ess. vol. iv. p. 275.

it may be removed without any hazard of cutting the artery.

This is the light in which I have been led to consider the use and abuse of the needle and ligature in tying the blood vessels, and shall now proceed to enquire into the method of suppressing the hæmorrhage by fungous substances, which, like the ligature, will appear to have their advantage and inconvenience.

C H A P. III.

Of suppressing the hæmorrhage by the application of fungous substances, by coagulated blood, by astringents, and by perpendicular pressure.

THE late success which has attended the application of fungous substances is a full proof that an hæmorrhage from large arteries may often be effectually suppressed by their use; and it at the same time points out the truth of the doctrine advanced, and what little assistance in this case is wanting.

But the manner of applying funguses makes a material difference in regard to success; for if they are pressed close against the end of the vessel, they intercept the passage of the blood; and the artery closes itself up in the manner described: whereas, when this circumstance is not observed, and they are only laid near to the orifice, in the manner Cheselden * used

* Phil. Transf. N^o 478. p. 33.

sponge,

sponge, they suppress the hæmorrhage by choaking up the mouth of the vessel with coagulated blood, which hinders its being closed; and though it stops the bleeding at present, yet it may be the source of a future hæmorrhage.

This is evident from the experiments made by La Foss *, where the coagulated blood, which filled the end of the artery, was formed into a cone with its apex towards the heart; consequently, if the plug happens to extend to the next collateral branch, a fresh flux of blood must ensue upon its coming away; for it does not unite with the vessel, as some have imagined.

I know there are instances, where an orifice made in an artery has been stopped with a clot of solid blood, which adhering firmly to the cicatrix of the integuments, produced a considerable callosity, and which seems to have given rise to this opinion. But it must be observed in these cases, the wound was

* Philos. Transf. vol. xlix. part. art. 10 & 11.

cured without coming to suppuration; whereas when the air has free access, we well know a putrefaction of the coagulated blood, as well as digestion, is always the consequence; and I make no doubt but the separation of coagulated-blood is one cause why a fresh bleeding has sometimes come on after the inflammation was abated, and matter began to be freely discharged. In a very late instance, where the bleeding from a divided artery had been suppressed by coagulated blood, I saw it renewed again next day by taking this blood away; the artery bleeding in the same manner as when it was first opened; but upon pressing it betwixt my fingers it was soon effectually closed. Hence we may observe, that the practice of laying allum, or any thing else, at the end of the artery to coagulate the blood, is very improper, as every impediment to the contraction of the vessel should on the contrary be removed.

This leads me to take notice of Petit's opinion, who imagined that the hæmorrhage from divided arteries was always suppressed by plugs of blood within the vessel; because
he

he found in some of them, after the death of the patient, coagulated blood, which extended itself upwards a considerable way.

But notwithstanding this, it is very probable that the hæmorrhage was stopped by the natural contraction of the vessel; for we find in the two waggoners mentioned by *Monf. Fagot* *, where, after death, coagulated blood was found in the same manner, “ their extremities were contracted and straitened, as if they had been tied.” And in the many experiments I have made on this occasion, I never found coagulated blood but once; and then the extremity of the artery was close contracted †.

Pouteau ‡ opened several arteries, and never found any coagulum; nor is there any

* *Philos. Transf.* for 1753; or *Mr. Warner's Cases*, p. 136.

† It was in the artery of a large dog which was strangled.—The horses, &c. were killed by being bled to death in the usual manner, which seems to prove that the coagula are not formed while the blood circulates regularly, but when the animal is near dying, or immediately after death.

‡ *Melanges des Chirurg.* p. 314.

coagulum found in the umbilical vessels of children after death: from all which may we not conclude, that this circumstance is merely accidental, and no step taken by nature, who is always uniform, if no impediment is in the way? Indeed, I think with some other writers†, that it is of the same kind, and produced in the same manner as the fibrous blood we often find in the great arteries near the heart: that which I saw had exactly the same appearance; nor did it seem sufficient to have blocked up the vessel. What is already said about coagulated blood preventing the contraction of the vessel, here also takes place; and was it extended to the extremity of the artery, putrefaction and its consequences must of course ensue, from its being in contact with the air.

It follows then, that whatever fungus is used, it should be pressed close to the end of the vessel; and that kind which adheres closest should be chosen. Mr. White says‡ that sponge is on this account preferable; and if

† Gouch, Pouteau.

‡ Loc. cit.

his directions, in regard to the choice, preparation, and manner of applying it, be observed, I believe he says true; but even this sticks the fastest when it is least wanted; for though after a while it adheres so firm, that it is removed with difficulty, yet, till the parts begin to swell and become moist, the adhesion is very slight.

Bandage therefore must be carefully applied to preserve it in its proper situation; and if this circumstance had been duly attended to, instead of relying upon a specific property in agaric, better success would probably have attended it when in vogue; for where agaric itself proved ineffectual, tight bandage and common dressings suppressed the hæmorrhage. And we might produce innumerable instances which prove, that whatever is kept firm upon the end of the vessel is sufficient for the purpose.—However, if what is said about tying the great arteries be true, most surgeons, I imagine, will still secure them with the ligature; for no sort of bandage can with safety in amputations be so applied, but the fungus may sometimes be displaced by spasms, coughing,

ing, vomiting, or the like: and should an hæmorrhage return from these vessels, we know death may ensue from the loss of no very large quantity of blood. Mr. Sharp's † patient, in whom the vessels burst open three hours and half after he had applied agaric, died in about twenty minutes with the loss of less than thirty ounces of blood, including what was lost in the operation: nor could assistance be speedy enough to prevent this catastrophe, though it was upon the spot when the hæmorrhage returned; and how much more likely is this to be the case in private practice, especially in the country, where the person obliged to be intrusted with our patient is often an intire stranger to chirurgical operations?

But suppose our assistant should be so lucky as to compress the tourniquet time enough to save the patient's life, yet it is probable a quantity of blood will often be lost, that may be injurious to him; for though the loss of some blood from this accident may be serviceable, when the patient is not much re-

† Phil. Transf. vol. xlviii. part 2. art. 78.

duced by the disease †; on the other hand, the loss of a few ounces, when he is become weak, will be very improper, and very likely retard the recovery of his health: and we may observe, even in strong habits, that the discharge of blood ought not to be committed to chance, but intirely directed by the judgment of the surgeon. And though it should happen that very little blood is lost, the patient may not only undergo great pain from the compressure, till the surgeon can be called, perhaps from a considerable distance, but the parts may be much injured by the fluids being so long in a state of stagnation.

But this inconvenience will for the most part attend the use of this remedy in amputation of the limbs; for all agree that it is necessary to keep the limb compressed a considerable time with the tourniquet, and which will also in all probability overbalance the pain caused in using the needle and ligature. Nor can we help thinking but some mistake hap-

† See Mr. Warner's Cases, case 44.

pened in describing those cases, where we are told, though the tourniquet was kept compressed for half an hour, that the patient was remarkably easy during that time. Mr. Sharp's * patient, when he used agaric, complained *grievously* of pain arising from the tourniquet; and my patients tell me, it is the worst part of the operation: besides, I have observed when a piece of fungus adheres close, it gives very considerable pain in being removed; so that upon the whole, this method of securing the great vessels is attended with more pain and less safety, than the ligature when properly applied.

This reasoning also holds good in regard to the lesser arteries, when they are surrounded with the cellular or adipose membrane only; though it cannot be extended to the tying of those which are situated amongst the muscles, because, as is already observed, the ligature is here attended with considerable pain; nor is the tourniquet in this case wanted; and I make no doubt, but these vessels may in ge-

* Phil. Transf. vol. xlviii. part 2. art. 78.

neral be trusted with sponge, or any thing else that adheres close to their extremities: but the sponge should be removed the first or second dressing, otherwise the new flesh growing into its pores will cause an increase of pain in the removal.

On the other hand, if the bleeding should happen to return, though on account of the size of the vessels it might not be dangerous, yet even here more blood might be discharged than it would be prudent to lose; a fresh hæmorrhage is always alarming to the patient; and as momentary pain seems to be the only inconvenience, perhaps many surgeons will think it best to leave their patients in perfect security: and we may just observe, that in many operations the ligature must of course be used upon all the vessels, as it will be necessary to stop the bleeding as we go on.

Nevertheless, when the flesh is become tender, and gives way to the ligature, sponge seems to be the best remedy; for though the large vessels might be pulled out, and tied in

the manner Dionis * describes, yet, being undefended, the end would commonly separate; and unless the ligature was placed near its extremity, sometimes bring on a fresh hæmorrhage in the manner already observed. And this was most probably the reason why Parey had more certain success, when he took in, along with the vessel, some of the adjacent parts, than when he inclosed it alone in the ligature.

Where the vessels are so deeply situated as not to be come at with the needle, the same kind of application must have preference, if it can be laid close to the mouth of the artery; and it succeeds better in this case, as the sides of the wound assist in keeping it in its proper situation: but before it is applied, it seems necessary to examine whether the artery is wholly divided; for without this caution we may sometimes be disappointed in our expectation, and ascribe insufficiency to

* He describes different methods, but that is here referred to, where the thread is passed through the end of the vessel to prevent its being pushed off by the impulse of the blood. See chap. on Amputation,

this method, as was done to the agaric †, when the want of success was owing to the vessel being in part divided, whence it was incapable of intercepting the passage of the blood. Nor should we forget, that in wounds which admit of cure by an immediate union of their divided parts, fungous substances are unnecessary, as the common method of dressing effectually suppresses the bleeding, though it is from considerable arteries.

However, if the artery is large, and any difficulty occurs, if the part will admit of the practice of dilating the wound, perhaps it may seem more proper by that means to use the ligature, especially if it adheres to an undivided muscle or the bone, and bandage cannot be conveniently applied; and where the principal trunk of a large artery is wounded in a longitudinal direction, Mr. Lambert's ‡ method of sewing it up should, I think, be tried.

† See Neal on Agaric, p. 35.

‡ Med. Inq. vol. ii. p. 360.

When an hæmorrhage arises from a thin state of the blood, and the discharge is from the whole surface of the wound, *puff ball* seems preferable to sponge, or the like, as the blood would probably escape through its pores. In this case, with tight bandage it has answered my purpose, till internal medicines had their proper effect: and if upon trial it should prove successful under the like circumstances, will it not be more proper than *styptics* or *astringents*, &c. as these harden the fibres, and prevent digestion, from which inconvenience this remedy is free? Nor do I apprehend the bandage will be so unartfully applied, as to bring on a flux of blood by compressing the veins, as I imagine in general this obvious cause of an hæmorrhage is well understood, being pointed out by several writers on surgery, and clearly demonstrated by *Monro* *.

Perhaps some will think that *styptics* and *astringents* will forward the contraction of the vessels: but we may learn how little they

* *Ed. Med. Ess.* vol. iv. p. 271.

are wanted, from the artery in the young fellow's arm, which was evidently relaxed and weak, closing itself without any assistance; and I am persuaded, from some experiments I have made, that these applications, instead of assisting, would, if they were not hindered by mixing with the blood in wounds, rather prevent the collapsing of the vessel by hardening its fibres. And however contrary this doctrine may be to the generally received opinion, experience is certainly in its favour; for though by coagulating the blood, they might succeed upon very small arteries, yet, being applied to those which were large, they were always found insufficient to suppress the bleeding, unless tight bandage was at the same time used, and to which I think it is clear the success was owing: for many of these compositions, which were thought to be astringents, had certainly no other property as blood-staunchers than that of choaking up the mouths of the vessels *.

* See Parey, p. 328. Hildanus, p. 812. Clow's Surgery, p. 27.

It is obvious that the fungus, when used, must be kept in its proper situation by bandage differently applied, according to the part wounded; and in this matter every surgeon's own judgment will best direct him. However we may just observe, that in amputations good sticking plaister, as advised by Mr. White *, and keeping the hand pressed harder against the part for a few hours, may often be sufficient; though the machine recommended by Mr. Gooch † will, probably, be more certain; and when this is not at hand, a circular piece of leather may be made to answer nearly the same purpose.

This piece of leather must be large enough to cover the end of the stump, and near its edge must be cut four flits in opposite directions, that will admit each a fillet.—Supposing a leg taken off below the knee, two fillets being passed through these flits crossways, and under a roller or a piece of cloth that goes round the thigh, above the knee, must be

* Essay on Spunge.

† Cases, p. 131 and 141.

brought back again, and tied upon the end of the stump, by which means the dressings will be fixed, and any degree of pressure may be made: and this bandage, if it is kept from slipping down, by being fastened with filleting to a roller round the waist, serves equally well when we amputate above the knee. Nor do I recommend this method without experience; for having amputated a leg, where the blood was extremely poor, and the flesh very tender, the ligatures were forced off the vessels a few hours after the operation, by a fit of coughing and vomiting; I immediately applied the bandage above-mentioned, with bolsters of dry lint, which effectually answered the purpose: for, though the patient vomited and coughed several times afterwards, the hæmorrhage did not return.

Indeed bandage seems hitherto to have proved less serviceable than it might have been, merely from imagining it would be useless, unless the sides of the vessels were brought together in close contact; whereas, had the pressure been made only upon the end of the vessel, and just sufficient to resist the im-

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pulse of the blood, it might much oftener have been used without inconvenience, and with better success, as there is reason to think from many instances.

We have only further to add on this head, that where the wounded artery cannot be come at, pressure is still the only remedy; and where things are so circumstanced that we are obliged to choak up the mouths of the vessels with coagulated blood, it seems necessary, for reasons already given, to make a pressure, if it can be done, against the end of the artery, that the contraction beyond the plug may more certainly take place.

C H A P. IV.

Of suppressing hæmorrhages by cauteries, caustics, &c.

BESIDES the methods above-mentioned, Mr. Warner * has shewn, that when an artery is opened in the roof of the mouth, the actual cautery is sometimes necessary to stop the bleeding: and many years ago, after extirpating a tumor from this part, I was obliged, for the same reasons, to have recourse to the same remedy; but the iron was no hotter than just sufficient to form the neighbouring parts into an eschar upon the end of the artery; by which means the course of the blood was intercepted, and the vessel left at liberty to close itself up; whereas when the cautery is very hot, it not only burns the end of the artery a considerable way, but hardening its fibres beyond the eschar, renders it incapable of collapsing; so that it is no wonder an hæmor-

* Cases, p. 38.

rhage should so often ensue upon the separation of the dead parts.

However, the cautery is at all times a cruel application, and should be avoided, if possible: nor do I now call to mind any other part where its use can be wanted. But if this is cruel, the potential cautery is more so, as it spreads itself further into the neighbouring parts; and yet it is not very uncommon for surgeons in performing operations to apply lint soaked in scalding oil of turpentine, where the artery, though not very large, cannot be readily come at: and this piece of cruelty is still aggravated, when we consider that a few minutes pressure would, in all probability, have alone been sufficient for the purpose.

Caustics, &c. are, I believe, in general, laid aside in suppressing hæmorrhages; and therefore we need only observe, that, though they do not, by hardening the sides of the artery, render it incapable of collapsing above the part destroyed, yet, by causing its end to separate, their use is directly contrary to right practice; and consequently those advise ill,
who

who give up every advantage gained by the ligature, in afterwards applying a piece of vitriol.

But all these errors in the choice of remedies, or their application, have arose from the true principles of suppressing hæmorrhages not being previously investigated; it will therefore give great pleasure to the author of this little essay, if it appears that he has set in its proper light this important, though common operation.

T H E E N D.

